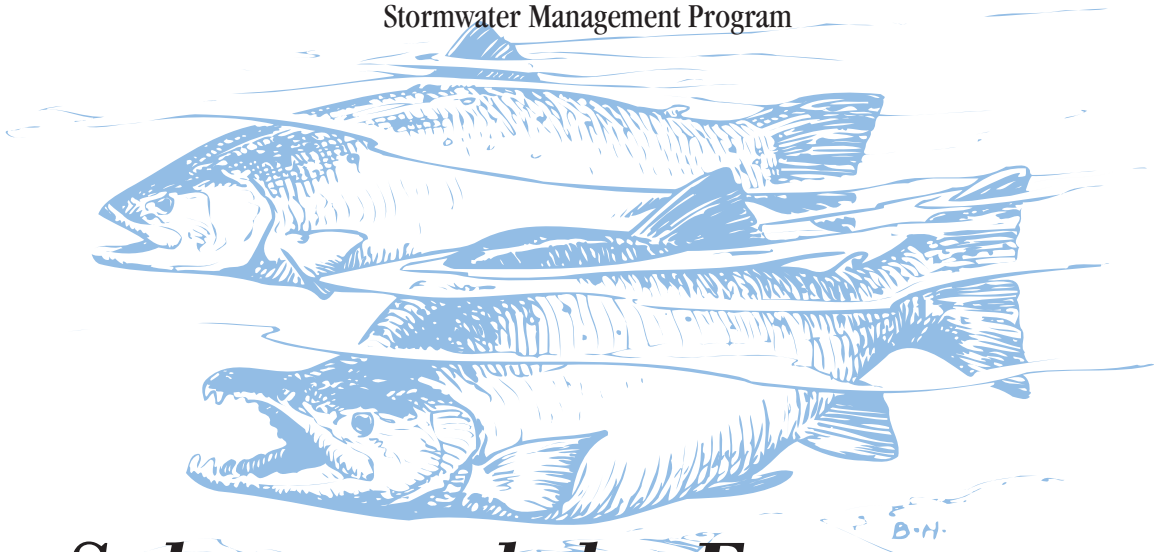
SPLASH!
Stormwater Pollution: Learn and Share

A Local Water Quality Curriculum

City of Eugene
Stormwater Management Program



Salmon and the Ecosystem:

A Curriculum for Grades Nine through Twelve

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Salmon and the Ecosystem

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Lesson 1:

An Ecosystem Out of Balance

Salmon in the Pacific Northwest

Objective: This unit explores the complex role salmon play in the Pacific Northwest ecosystem, the factors that have contributed to the decline of salmon populations, and the impact of losing a species that is key to the health of the entire ecosystem. The unit was written to be used with the fourth and fifth grade Ecosystems science kit and as an extension to the sixth through eigth grade Splash! units.

Teacher Background

What Is a Keystone Species?

A keystone species is a species whose presence contributes to a diversity of life and whose extinction would consequently lead to the extinction of other forms of life. Keystone species help to support the ecosystem (entire community of life) of which they are a part.

Older than the Ice Ages

Wild salmon are a **keystone species** in the Pacific Northwest. The health of salmon populations in the Pacific Northwest is a reflection of the health of our rivers and ecosystems.

The ecosystem in the Pacific Northwest evolved around the plentiful salmon runs that have occurred since before the Ice Ages. Salmon have survived for millions of years; enduring mud flows caused by volcanic eruptions and ice sheets that covered the region during the Ice Ages. Fossil records have identified a diverse number of salmonid species in the northwest, including the saber-toothed salmon (*Smilodonichthys rastrosus*), an intriguing relative of today's salmon. Fossils found in eastern Oregon revealed the saber-toothed salmon was an enormous fish that reached lengths of eight feet long and sported "fangs" that were almost 2" long. The saber-toothed salmon lived at the same time as many saber-toothed cats and, along with the cats, became extinct in the early Pliocene epoch.

The salmon's life cycle evolved as they adapted to periods of ice and water in the nutrient-poor freshwater streams in the Pacific Northwest. The lack of nutrients in the streams where salmon

hatch was an important factor in the evolution of the salmon's migration to the ocean. While freshwater streams provide ideal habitat for spawning and the growth of juvenile salmon, the ocean provides the rich food and nutrients adult salmon need to grow. For millions of years, people, other animals and the forests have depended on salmon as a food source rich with nutrients brought back with them from the ocean.

Wild salmon are an **anadromous** fish; born in freshwater, migrating to the saltwater ocean and then returning to their home stream to spawn. In their life cycle, freshwater habitats are used for spawning, incubation and the rearing of juvenile fish. During the juvenile phase, the salmon migrate to estuaries along the ocean where they make the adjustment between fresh and salt water. After a period of time in the estuaries, young adult salmon head to the ocean where they feed on a rich diet of invertebrates and fish. The marine-derived nutrients salmon accumulated in the ocean play a valuable role in sustaining the Pacific Northwest ecosystem and in salmon survival.

Long Ago: A Perfect Balance

Over 100 years ago, salmon were plentiful in the Pacific Northwest. Stories were told of salmon runs on the Columbia River being so large people could walk across the river on the backs of the salmon! The salmon runs went far inland to rivers and streams in Washington, Oregon, Idaho and California. At that time, the estimated biomass of salmon returning each year was almost 500 million pounds. Spawning salmon returning from the ocean provided food for many bird, reptile, amphibian species, and native people. The salmon also had a large role in the ecosystem even after dying: their decaying bodies fertilized trees and plants along the shores of streams, provided nutrients to aquatic organisms, and perpetuated the species by being a food source for newly hatched salmon. Bears, bald eagles, wolves and other animals that fed on salmon dragged salmon carcasses into the forest, further spreading nutrients to the land. Native Americans also took salmon from the streams to the forests and sometimes traded dried salmon to tribes on the other side of the continental divide, further spreading the biomass. The constant recycling of nutrients, with salmon bringing important nutrients from the distant ocean to the forest, kept the ecosystem healthy and in balance.

The Beginning of the Decline

In the late 1800's, people living in the Pacific Northwest began harvesting salmon commercially. Salmon canneries sprung up on the Columbia River. Millions of pounds of

salmon were caught yearly and canned between the 1860's and 1930. After 1930, salmon numbers began to decline and continue to decline today. The building of hydroelectric dams also contributed to the decline in populations by blocking the routes to traditional spawning grounds. Overfishing, habitat destruction, water pollution, elevated water temperatures, erosion and many other factors have reduced salmon numbers even more. Today, 27 stocks of salmon are extinct and over 100 stocks of salmon are at high risk of extinction. Almost 100 more stocks of salmon are in danger.

Until recently, the decline in salmon runs and loss of stocks has been only viewed as an economic loss for the fishing industry. The ecological significance of salmon in the ecosystem was not considered a factor. Scientists now recognize salmon play a key role in delivering nutrients to streams and rivers throughout the Pacific Northwest. Studies of historical salmon runs have determined that the total biomass of salmon returning from the ocean to spawn was 320 to 500 million pounds. Because of the sharp decline in salmon populations, it is estimated that only 3%-7% of the once plentiful marine-derived biomass is being delivered by salmon to rivers and streams in the Pacific Northwest. This loss of biomass affects the entire ecosystem and also has dire consequences in the salmon populations. Because juvenile salmon depend on the nutrients from the rotting carcasses of the adult salmon for survival, the reduction in numbers of returning adult salmon mean fewer juveniles survive to make the journey to the ocean to continue the cycle. With reduced food supplies, those that do survive are often smaller. The reduction of salmon runs also impacts the populations of small aquatic organisms that feed on the decaying carcasses. This further reduces food sources available for young salmon and other species that depend on aquatic invertebrates during their juvenile phases.

The loss of biomass also has an impact on predator species. In the Pacific Northwest, approximately 135 species of terrestrial and marine mammals, birds, reptiles and amphibians have a direct or indirect relationship with salmon. Nine species have a very strong link to salmon. Black bears, grizzly bears, killer whales, river otters, Caspian terns, common mergansers, harlequin ducks and osprey are all major salmon eaters. The loss of salmon greatly reduces the food source they need for survival.

What is a stock?

Each species of salmon is made up of many stocks, or subgroups of species (sometimes called a race). Salmon that belong to different stocks can interbreed, but usually do not because of geographic or seasonal barriers. Stocks migrate to different streams to spawn, or spawn in the same river in different seasons. Each stock represents a slightly different genetic makeup of fish, and the greater number of stocks, the greater genetic diversity for each salmon species — an important feature for adapting to environmental changes and ensuring the future of that species.

Salmon need forests...and forests need salmon!

Just as the forests depend on migrating salmon to deliver nutrients from the ocean, salmon depend on forests for the habitat they need to survive. Healthy forests influence streams in ways we might not think about. The shade of the forest canopy keeps water temperatures cool, creating ideal conditions for salmon spawning. The root systems of trees and shrubs on stream banks hold soil in place, reducing erosion. Woody debris from trees moderates water flow, reducing the scouring of the stream bed during heavy water flows. All of these factors contribute to healthy streams that salmon need to survive.

The influence salmon have on forests is even more intriguing. The riparian areas along mountain streams are as lush and green as a well-kept garden. We all know that to keep our gardens healthy and growing we need to feed the plants. Since mountain streams contain few nutrients, how do the plants stay lush and green? Salmon provide a natural fertilizer for the forests. Salmon that return to their native streams die soon after spawning. Their bodies are washed by stream currents to the shore, where they decay. The rich nutrients carried back from the ocean in muscle and bones are washed by rainwater into the soil. The nutrients are absorbed by the roots and distributed throughout the entire plant. (See handout, **Salmon and Sitka Spruce: A Mutually Dependent Relationship**)

Birds and animals also play a part in helping carry these nutrients deeper into the forests. Birds and bears carry salmon carcasses far inland from streams. The parts of the salmon they don't eat are left to decay on the forest floor and provide natural fertilizer for surrounding plants. The nutrients are also deposited with bird and animal waste far from rivers and streams.

Although scientists knew salmon had a far-reaching impact on ecosystems, they only recently discovered how to prove it by tracing certain nutrients from the ocean to the forest. The mystery was solved by identifying specific chemical elements unique to ocean food sources eaten by salmon. One of those elements, ^{15}N, a stable isotope of nitrogen, is found primarily in marine algae.

Eroded soil from construction sites is carried with rainwater into storm drains that lead directly to local waterways. Silt and dirt clog salmon spawning grounds and smother salmon eggs.

Plankton that eat marine algae are consumed by other organisms. The isotope is passed from organism to organism and becomes further concentrated as it moves up the food chain. The ^{15}N isotope is found in abundance in the body tissues of salmon. The fact that the ^{15}N isotope has been found in trees, leaves, and insects hundreds of miles away from the ocean proves the tremendous impact salmon have on a larger scale.

A closer look at the causes of salmon decline

Many factors have contributed to the decline in salmon populations in the Pacific Northwest. Massive overharvest, the construction of hydropower dams, poor logging and ranching practices, and polluted rivers have all contributed to the loss of salmon runs in the Pacific Northwest.

Overharvest

Overfishing has been a major factor in decimating salmon populations. In the early 1900's, canneries on the Columbia River processed millions of pounds of salmon. The salmon that made it past the purse seins and gillnets used by fishing boats in the ocean then faced fish traps placed in the rivers. Whatever salmon that remained were fished by Native Americans who lived along the river.

Hydropower Dams

Hydropower dams have had a major impact on salmon survival. Dams block upstream migration and many fish are sucked into the dam's powerful turbines and perish. To mitigate salmon losses, many dams have fish ladders that are constructed to allow the salmon safe passage. Although fish ladders help, they are not entirely effective in helping adult salmon make it back to their spawning areas.

Poor Land Management

Habitat destruction is another factor that has contributed to salmon's decline. Poorly managed livestock grazing, bad logging practices, and unprotected construction sites have increased the amount of runoff from the land to streams. Silt and dirt carried with runoff cover stream bottoms, smothering salmon eggs and embryos and destroying spawning areas.

A Modern Problem: Polluted Stormwater Runoff

At one time, industrial discharge and lack of sewage treatment in cities were the major causes of water pollution. The passage of environmental legislation and improved sewage treatment in our cities have both contributed to a dramatic reduction of industrial pollutants entering rivers and waterways. However, rivers are still being polluted in a way that is

Toxic Metals

A Seattle Post-Intelligencer story from April 14, 2003 reported a coho salmon kill-off in a creek that receives stormwater runoff from Sea-Tac airport. The deaths occurred during fall, coinciding with the start of seasonal rains. According to the story, residents had expressed concern about stormwater pollution from airport runways and maintenance areas entering local creeks.

The Washington State Department of Ecology has estimated that more than 803 million gallons of stormwater runoff comes from the airport each year. The most contaminated runoff (about 300 million gallons) is treated; the rest runs into holding ponds and is later released into two local creeks. Water samples taken from the creeks revealed extremely high levels of copper and zinc. Copper has been identified as highly toxic to salmonids and even more toxic when combined in water with zinc and other metals (Environmental Contaminants Encyclopedia, National Park Service, 1997).

Although the exact cause of the fish kill-off has not been determined, the state Department of Fish and Wildlife concluded that exposure to chemicals was probably a factor in the deaths.

Something to think about:
Salmon are often compared to the canary in the coal mine. What significance does this analogy have in the Pacific Northwest?

harder to detect. Rivers are being polluted by "non-point source pollution," or pollution that does not come from one specific, identifiable location. Stormwater runoff from agricultural areas and cities is now the major source of pollution in our waterways.

What is stormwater runoff? Our modified landscape now includes roads, parking lots, and buildings that have replaced natural vegetation. Any surface that prevents rainwater and snowmelt from percolating into the ground is called an "impervious surface." Rainwater or snowmelt that runs across these impervious surfaces is called "stormwater." Any time it rains, oil, dirt, metals, and chemicals are carried with stormwater into local waterways. In many cities, stormwater is not treated or filtered before entering streams and rivers.

What's in Stormwater?

The pollutants carried along with stormwater combine to become a toxic mix that enter our rivers. Spilled paint, oil slicks and garbage are some of the "visible" pollutants we commonly see. However, many pollutants are not visible once they enter a waterway. These invisible pollutants are just as harmful as those we can see.

A Toxic Mix

Fertilizers and pesticides used in yards, gardens and in farm fields are major pollutants that harm fish and other aquatic organisms and destroy habitat. Developed to harm or kill living organisms, pesticides (which include insecticides, herbicides, rodenticides and fungicides) continue to work once they enter streams and rivers.

Pesticides have been identified as a major pollutant that affect the salmon life cycle and salmon survival. Pesticides can cause behavioral changes in salmon, harm their reproductive systems and impair migration. Indirectly, pesticides cause harm to salmon by killing insects and other food sources along with changing the aquatic environment.

Many pesticides have been identified as directly or indirectly harmful to salmon. The Environmental Protection Agency lists approximately 36 pesticides commonly used in Oregon that have been found to harm fish (Lind, P. 2002). Many rivers, including the Willamette, contain some of these pesticides at or above levels known to harm fish.

One of the most common pesticides detected in water is 2,4-D, a chemical found in almost all weed and feed products. In the U.S., almost 70 million pounds of pesticide are applied to lawns per year. Identified as a neurotoxicant, 2,4-D impairs swimming ability in juvenile salmon. Impaired salmon cannot forage for food, escape predators or migrate.

Another pesticide, Diazinon, a neurotoxic insecticide commonly used on lawns, golf courses, and in homes, is harmful to salmon exposed to even very small doses. (Although production of diazinon will be stopped in 2004, the chemical may be sold until all remaining stock is gone.) The Environmental Protection Agency has estimated that over 13 million pounds of diazinon are applied in the United States every year. Diazinon has been found throughout the United States in rivers, groundwater, rain, and fog. Studies have discovered that small, nonlethal doses of diazinon inhibits the salmon's sense of smell (Scholz, Truelove, et.al. 2000). Salmon depend on their sense of smell to detect predators and use olfactory cues to migrate back to their home streams to spawn. Exposure to diazinon makes salmon easy targets for predators and disrupts their journey back to their home stream to spawn.

Stormwater runoff causes pollution "pulses" directly after a heavy rainfall. Depending on the length and intensity of the rainy period, these pulses can last for one day or up to a few weeks. Stormwater is especially laden with oil, chemicals and debris when rains occur after a dry period. An example of how deadly these pulses of pollution can be was demonstrated by a recent event in the Seattle area.

Since 1999, coho salmon migrating into streams in urban areas near Seattle have experienced unusual and sudden die-offs before spawning. Coho salmon, the first fish to migrate up the urban streams to spawn in the fall, were seen swimming erratically. Many of the salmon died before spawning. Since the erratic behavior and sudden death of the salmon coincides with the first fall rains, scientists believe the deaths are a direct result of the "first flush" of polluted stormwater runoff. (Runoff from the first fall rains is often the most toxic as it carries a summer's worth of accumulated pollutants into the storm drain system.) This is one of the first times polluted stormwater has been implicated as the direct cause of sudden salmon deaths.

Other Pollutants

Automobiles and trucks also contribute to stormwater pollution. Leaking automotive fluids, metals from deteriorating parts, and vehicle exhaust all make their way with rainwater into the storm system. Paint, solvents, dirt, garbage and pet waste are other common pollutants.

Water Temperature

Water temperature is also a critical factor influencing the salmon life cycle. Salmon need cool water for survival. High water temperatures can make salmon susceptible to disease and affect migration and spawning. It may not be obvious, but the temperatures in streams and rivers can be influenced by stormwater runoff. Streets and parking lots not shaded by trees become superheated when the sun is out and can have a significant impact on nearby waterways. This is especially a problem in the spring and fall when showers are interrupted by sun breaks. The loss of trees along streams and rivers also exposes the water to the heat of the sun.

What Can We Do to Help Salmon?

Debates over fishing quotas, breaching dams, logging, and ranching practices have gone on for years. Since these issues involve government policy and regulations, it will be a long time before solutions are found for some of these problems. While these issues are being debated, individuals can focus on water quality and what they can do to keep water clean.

The choices we make in our every day lives can have an impact on water quality and the chances for salmon's survival. Unlike some other forms of pollution, stormwater pollution can be prevented by changing our behaviors. How we maintain our cars, care for our yards, deal with construction sites, and even clean up after our pets can make the difference between having clean or polluted waterways.

Can the bridge be fixed?

The role of salmon in the Pacific Northwest ecosystem is much greater than we realize. The salmon function as a bridge between ocean and forest ecosystems that are separated by a great distance. The loss of salmon in the Pacific Northwest weakens that bridge and continued losses could eventually cause an ecosystem failure.

Already, studies have indicated some of the stream ecosystems in the Northwest may be destined for an ecosystem failure due to the diminished salmon runs. Where do we start to fix what has taken generations to destroy? Is it too late to repair the damage that has been done?

Exercises and Activities:

Activity 1: Salmon Survival: Choices and Consequences. Follow directions in Teacher's Instructions, Activity 1. Copy and distribute Student handouts A, B, and C.

Activity 2: Stormwater Pollution Match-up Game. Follow directions included on Teacher's Instructions, Activity 2. (Game cards included.)

Activity 3: Can lawns kill salmon? Copy and distribute Teacher and Student Handouts "A, B and C" and Supplemental Handouts "A and B"for Activity 3.

Activity 4: Salmon of the future. Copy and distribute Teacher and Student Handout "A" and Student Handout "B" for Activity 4.

Activity 5: Salmon and Sitka Spruce. Copy and distribute Student Handout for Activity 5.

Activity 6: Tyee's Magnificent Journey. Copy and distribute Student Handout and Student Activity Cards for Activity 6.

References

Lind, P. 2002. *Poisoned waters: pesticide contamination of waters and solutions to protect pacific salmon.* Eugene, OR

Scholz, Truelove, et.al. 2000. *Diazinon disrupts antipredator and homing behaviors in chinook salmon (Onchorynchus tshawytscha).* Can. J. Fish Aquatic Science 57: 1911-1918.

Lesson 2:

Food Chains and Food Webs

The Salmon Connection

Teacher Background

All organisms within an ecosystem are part of a complex web of living things that use and convert energy to sustain life. Many factors, **biotic** (living) and **abiotic** (non-living), can affect the availability of energy and nutrients within an ecosystem.

What is a food chain?

The food chain is the passing of energy and nutrients from one organism to the next. Food chains are linear and can be simply described as "who eats what." Since species interact within an ecosystem, and many animals eat more than one thing, food chains weave together to form more complex food webs.

An example of a simple aquatic food chain would be phytoplankton-zooplankton-squid-salmon-killer whale. Phytoplankton produce their own food by converting the energy of the sun into sugar through photosynthesis. This energy is passed along the food chain as zooplankton eat phytoplankton, squid eat zooplankton, and salmon feed on squid and other small fish before they begin their migration back to fresh water to spawn. Some salmon become food for killer whales. Ocean nutrients (nitrogen, phosphorus, carbon, etc.) also pass along the food chain and are deposited far upstream when salmon spawn and die.

That simple food chain becomes part of a food web when you factor in the other animals that eat salmon. Many species depend on salmon as a major food source, including bears, eagles, and river otters. Dead salmon are also a source of nutrients for small aquatic invertebrates in fresh water streams. The food chains of all of these species interweave with the salmon's to form a more complex food web. Food webs can be very fragile and any catastrophic event that adversely impacts one major food source could cause the entire

Something to think about:

Ecosystems run on solar energy which is abundant, nonpolluting, constant, and everlasting.

Brainstorm: Has there ever been an event or time when the amount solar energy has been reduced in an ecosystem? If so, why and what was the result? (Hint: What theories exist regarding the disappearance of dinosaurs?)

web to collapse. (See example of El Niño.)

Within an ecosystem, biotic and abiotic factors can influence the availability of energy and nutrients. With the help of students, use Discussion 1 to list biotic and abiotic elements that can affect the food chain. Create a list on the board, leaving room to add information from Discussion 2.

Discussion 1:

All environments consist of biotic (living) and abiotic (non-living) elements. What are the abiotic and biotic factors in the salmon's environment and what natural phenomena can influence and/or change them?

Examples of abiotic factors and influences:

The ocean: sunlight, water temperature,
Influences: currents, El Niño
Rivers and streams: sunlight, water temperature, oxygen content, available minerals
Influences: streamside vegetation, streamflow, turbidity, pollution

Biotic factors:

Producers: Produce own food. Example: Phytoplankton make food for themselves by converting energy from the sun via photosynthesis. The energy flows up the food chain as one animal consumes the next.

Consumers: Feed on others. Primary: herbivores; secondary: carnivores and omnivores
Decomposers: Bacteria and fungi break down organic material.

Discussion 2:

Human activities can have a harmful affect on aquatic environments, disrupting the transfer of nutrients and energy through the food chain. Polluted runoff from paved areas degrades water quality and can directly harm fish and other aquatic organisms. As an example, pesticides can kill small aquatic organisms that are a major food source for fish. The reduced food source for fish results in smaller fish populations, which then affects the the consumers that eat fish. It is important to note the "domino effect" that occurs when a food chain becomes disrupted.

Question 1:

What human activities affect abiotic factors in an aquatic ecosystem?

Sun/shade: logging
Water temperature: Trees, paved streets (stormwater runnoff), industrial discharge from urban areas
Oxygen: algae blooms from polluted runoff (fertilizer)
Sediment and Turbidity: siltation from erosion
Stream flow: dams, floods, drought, diversion, filling

What human activities affect biotic factors in an aquatic ecosystem?

Producers: algae blooms from fertilizer runoff deplete oxygen available for other aquatic organisms
Consumers: oil, pesticides, and other pollutants can kill primary and secondary consumers

Question 2:

Can abiotic factors influence biotic factors in an environment?

The El Niño phenomenom gives us a perfect example of how an abiotic factor (weather) can impact an ecosystem, causing a domino effect on the food chain in that ecosystem. How do these changes affect the food web? The example below relates how El Niño can influence two different ecosystems and the food chain of two species; one beneficially and one harmfully.

Example: Ocean currents and water temperature influenced by the El Niño phenomenom result in more or less food available in an ecosystem. In El Niño years, cooler waters increase the production of zooplankton in Alaska during the spring. The increased food supply enhances the survival rate of juvenile salmon, which results in abundant numbers of adults returning to spawn in the following years. The abundance of spawning salmon provides more food for eagles, bears and many other species. The entire food web benefits.

The opposite happens in California. The El Niño phenomenom brings warmer ocean currents from the tropics to the west coast of the United States. Plankton production is dramatically reduced in the warmer water. Sardines, squid, anchovies and other sea creatures that feed on plankton die off or move north to cooler water, leaving less food for adult seals and sea lions. As a result, adult seals and sea lions are forced to spend more time hunting for food and less time feeding their young. The lack of food from their mothers results in a dramatic die-off of their young, and in the span of a year or two, the die-off affects the entire population. Both of these examples show how one abiotic factor can influence an entire food web as individual species in the web become more plentiful or are reduced.

Activity 7: The Salmon Food Chain and Food Web. Follow Teacher's Instructions for Activity 7. Element and organism nametags are included. Distribute Student Worksheet 1, *What is my Role in the Ecoystem?*

Another definition...

food pyramid

A graphic representation showing all the energy and biomass contained in each trophic level of an ecosystem at any given time, moving from producers up the food web to top-level consumers.

Additional Resources

Grades 9-12

The following additional resources have been selected to supplement the salmon curriculum. For more resources related to stormwater education, please refer to the Additonal Resources section of the SPLASH! curriculum for grades K-8.

Websites

www.wildsalmon.org

Geared toward older kids, this website focuses on wild salmon and river restoration.

www.riversmart.com

Kids will learn to become "Riversmart" about things they do at home. Includes a "Riversmart" quiz and a list of things kids and their parents can do to help keep rivers clean.

www.nwf.org/keepthewildalive/salmon/

The National Wildlife Federation's salmon website has lots of information about the natural history of chinook salmon, and science facts about habitat, their life cycle, and threats they face.

http://splash.metrokc.gov/wlr/waterres/salmonch.htm

This website has the Salmon Challenge, a fun, interactive game that shows kids how their decisons affect salmon and the environment. Developed by King County, Washington. Suitable for grades 4-9.

www.inforain.org/maparchive/salmon_nation.htm

This site has wonderfully detailed, color-coded maps showing the status of salmon in the Pacific Northwest. The maps clearly illustrate the dilemma of disappearing salmon stocks.

www.mckenziewatershedcouncil.org/mckenzieatlas/chinook_map.htm

Developed by the McKenzie Watershed Council, this site contains a printable map of the McKenzie River showing the spawning areas of the spring chinook salmon. The map also shows dams and hatcheries.

http://eesc.orst.edu/salmon/human/default.html

This website explores the human and natural influences on the salmon life cycle and environment. Contains very specific information about Oregon. Good information for teachers and students.

www.bpa.gov/power/pl/columbia/stories/Journey1.htm

Developed by the Bonneville Power Administration, this website tells the story of Oncorhynchus, a Pacific Northwest Salmon. The narrative follows the salmon through her entire life cycle, from freshwater to the ocean and back, and describes the perils she encounters along the way.

www.oregonlink.com/flyfishing/historicphotos/celiloplatforms.html

This website contains historic photos of Native Americans using traditional methods to catch and dry (preserve) salmon.

www.salmon.room.net/

Salmon Room has information about salmon the life cycle and a live salmon cam.

http://wdfw.wa.gov/wildwatch/

Live wildlife cams from Washington state, including a salmon cam.

www.sunnywalter.com/Apn-Mammals-Salmon.html#Gov

This website contains links to salmon cams and government agencies.

www.nceas.ucsb.edu/nceas-web/kids/

Kids Do Ecology. This website answers the question "what is ecology?" Kids can find out about food webs, abiotic and biotic factors in an ecosystem, and how to become an ecologist.

www.eugene-or.gov

The City of Eugene's salmon page has detailed information about spring Chinook salmon in the Willamette River and the Endangered Species Act. Use the quick links to go to the Planning Division's Salmon Recovery page.

Video

A Last Wild Salmon

A great educational video for students, A Last Wild Salmon shows the life cycle of the Pacific Northwest Salmon in great visual detail. This film has won a BCMPA Leo Award for Cinematography and was a finalist at the New York Film Festival. 1997. $24.99 Available from amazon.com.

The Great Age of Salmon and the Pacific American Fisheries Company of Bellingham (PAF)

This video brings to life a fascinating era in the history of commercial fishing at the last frontier. Featuring film footage dating back to 1926, and narrated by industry pioneer Stan Tarrant, The Great Age of Salmon & the PAF is the story of the early fishing industry in Alaska and the Pacific Northwest, and of the Pacific American Fisheries Company of Bellingham. 1996. $19.95 Available from amazon.com.

Last Chance for the Pacific Salmon

A call to action by Trout Unlimited and The Wilderness Society to improve forest management for the survival of salmon. The video details the condition of salmon and the causes of decline. Most of the commentary and examples are from Northern California. 1995. 60 minutes. A Terra Video production that is available by calling (800) 333-4350.

Fresh Waters Flowing

Explores the connection between humans and streams, revealing the links between human influences and the ability of a stream to support healthy biological communities. 1998, 20 minutes, $16, Adopt-a-Stream Foundation (425-316-8592)

Life Cycle of the Salmon

Captures the remarkable life story of the salmon with memorable images that reveal the salmon's world, often from their underwater point of view. 1999, 6 minutes, $10, Oregon Sea Grant (800-375-9360)

Return of the Salmon

Describes the status of salmon, their reliance on healthy watersheds, the historic causes of the current decline, and recent efforts to restore the fish to their native streams. 1995, 33 minutes, $25, Oregon Sea Grant (800-375-9360)

Salmon, Restoring the Legacy

A good overview of the issues at stake in salmon recovery under the Endangered Species Act. Video, 2000, 16 minutes, available by e-mailing rob.bingham@ci.seattle.wa.us or calling 1-877-SALMON -9

RedFish BlueFish

The Times-Independent describes RedFish BlueFish as a story of the damming of a wild river that expands to examine the broader problem of energy production, the philosophy behind Western culture, and perhaps the most fundamental conflict of this time: economy vs. ecology. Gripping natural cinematography and compelling music. Available from the City of Eugene Public Works. Call 682-8482 to check out the film.

Music

"Chinook Blues" by Alice De Micele on her album, Demons and Angels. Tells the first-person story of the hazards faced by a migrating Chinook Salmon.

"Come Blow Your Horn" by Tom Chapin on his album This Pretty Planet — A great song about every species' inherent worth.

"Have to Have a Habitat" by Bill Oliver (1982) A favorite. This is an environmental classic!

"The Web of Life" by Walkin' Jim Stoltz Wild Wind Records PO Box 160477 or #10 Aspen Court, Big Sky, MT 59716, 406-995-4906. e-mail: walkinjim@walkinjim.com

"Science Songs": Includes Food Chain Gang, Decomposers, and other earth, physical, and life science songs. Order from: www.songsforteaching.com/Hood.html

"Unintended Consequences" Eleven songs about household hazardous waste, groundwater, toxins, etc. Titles include: "Storm Drain Stenciling," "Excuse Me, Sir, That's My Aquifer," "We're All Connected," and "Shoppin' for a Better World," and many others. Includes eight panel foldout with all lyrics, $15 each. On CD; order from www.stanslaughter.com/curriculumres/ecomusic.html#intunemusic

Books

Note: All of the books listed are available at amazon.com. Many are available in paperback and can be purchased new or used.

Salmon Stream (Sharing Nature With Children Book) by Carol Reed-Jones; Michael S. Maydak, Illustrator. The book follows a salmon through its life, surrounding it vividly with forest, stream, ocean, and animals. Dawn Publications, 2001. ISBN 1584690135.

Swimmer by Shelley Gill; Shannon Cartwright, Illustrator. The Story of "Swimmer," a chinook salmon, who journeys 10,000 miles to complete her life cycle. Paws IV Publishing, 1995. ISBN 0934007233.

Salmon by Sylvia M. James; Paul Bachem, Illustrator. Mondo Publications, 2000. ISBN 1572558059.

Discovering Salmon by Nancy Field, Sally Machlis. Dog Eared Publications, 2003. ISBN 0941042057.

A Salmon for Simon by Betty Waterton, Ann Blades. A boy named Simon discovers the beauty of salmon as he tries to return a stranded salmon to the ocean. Groundwood Books, 1996. ISBN 0888992653.

Salmon Forest by David T. Suzuki and Sarah Ellis. A young girl, with help from her father, discovers how the forest and salmon need each other. Greystone Books, 2003. ISBN 1550549375.

Come Back Salmon by Molly Cone; photographs by Sidney Wheelwright. The story of how an elementary school in Washington state adopted a polluted stream that was once a spawning ground for salmon. Sierra Club Books for Children, 1994. ISBN 0871564890.

Return to the River by Roderick L. Haig-Brown. Return to the River is the story of a Chinook salmon told in novel form. The salmon is the main character in this unique natural history that follows one fish through her entire life cycle. Written in 1941, this book is a true classic. Globe Pequot Press (The Lyons Press, Falcon), 1997. Paperback. ISBN: 1558215816

Books

Salmon Without Rivers: A History of the Pacific Salmon Crisis by Jim Lichatowich. Salmon Without Rivers chronicles the history of salmon decline in the Northwest and discusses how and why restoration efforts have failed. This books offers a biologist's view of the complex problem of a species in peril. Island Press, October 1999. Hardcover. ISBN: 1559633603

Games

Salmon Life Cycle Game. The Salmon Life Cycle Game, an interactive science-based board game, was created by a group of agencies in Oregon and Washington to help students learn about ecosystems, the salmon life cycle, and the impact humans have on the environment. Developed for students in grades 6-10. Available from the City of Eugene Public Works. Call 682-8482 to request copies for your classroom.

The No-Know Game. This game, produced by the Water Education Foundation, is a fun, interactive way for students to learn about non-point source pollution and how to prevent stormwater pollution. Available from the City of Eugene Public Works. Call 682-8482 to request a copy for your classroom. (Note: Limited copies are available and will be distributed on a first-come, first-served basis.)

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Stormwater Pollution: Learn and Share

Salmon and the Ecosystem:
Activities

Student and Teacher Handouts
Grades 9-12

Salmon Survival: Choices and Consequences

Activity 1

Teacher's Instructions

Amount of Discussion Time Needed:
Approximately two hours.

Instructions:
Copy and distribute situation cards and Student Worksheet "A" to each student. Assign students to research each of the three possible options for the situations. Instruct students to write their research notes on the situation card and choose an action to take on each issue. After they have completed their research, have them compile their answers on Student Worksheet "A." In the classroom, have students share their research and the options they chose. After all of the questions have been discussed, have students use Handout "B" to score their answers and use the graph provided (Student Handout "C") to chart their points to see if their choices were "salmon friendly" or harmful to salmon and their habitat.

Question #1

Stakeholder: Manager of a local shopping mall

Issue: After 30 years, the landscaping in the parking areas at a local mall has become overgrown. The parking area covers almost 10 acres and has approximately 30 storm drains that carry runoff directly to a nearby river. Even during peak shopping times, the parking lot is never more than three-quarters full. The manager at the mall has come up with three plans to consider.

1. Remove all of the old plants and bark-o-mulch the planting areas.

2. Replace the plants with native trees and shrubs and remove some of the paved areas, replacing them with natural swales.

3. Tear out the landscaped areas and add pavement to make room for more parking.

Choice: # _____

Notes on research: _____

_____

_____

_____

_____

Question #2

Stakeholder: Local developer

Issue: A new subdivision is being built near the headwaters of a local creek. Because all of the runoff from the roofs, streets, and driveways will be carried through the storm drains directly to the creek, the developer would like to include some type of stormwater treatment feature in the subdivision. Cost is an issue. Here are some possibilities:

1. Creat a natural swale and above-ground retention pond to collect and filter stormwater before it flows to the creek. Landscape the pond with the same native plants found in the vicinity.

2. Include an underground detention tank that collects and filters stormwater before it is released into the creek. This system is not natural and not as effective as a swale and pond.

3. After studying the options, the developer decides a stormwater treatment feature will not be financially feasible.

Choice: # _____

Notes on research: _____

_____

_____

_____

_____

Question #3

Stakeholder: You

Issue: A new house is being built in your neighborhood. You have noticed lots of dirt from the construction site is being washed into the street by the rain. The construction trucks are also leaving a trail of mud from their tires when they leave the site. The storm drain in the street is getting clogged with all of this dirt. What do you do?

1. Do nothing. The rain will clean the street by washing all of the dirt down the storm drain.

2. Worry about it a little bit. Even though you know the dirt goes down the storm drain and is carried directly to the river, you figure the river has dirt in it anyway, so a little more won't hurt.

3. Ask your parents or teacher to call the local Public Works Department and find out if the building contractors can do anything to stop the erosion and keep the street clean.

Choice: # _____

Notes on research: _____

_____

_____

_____

_____

Question #4

Stakeholder: You

Issue: Your dad and mom like big, lush, green lawns. Lately, some areas of the lawn are turning brown. Your parents suspect crane flies are killing the lawn and want to put a pesticide on the lawn to kill the crane fly larvae.

1. Help put the pesticide on the lawn. Put some extra on the brown spots. You don't like the idea of insects killing the grass either!

2. Read the instructions on the package with your parents and follow them. Use only as much as you need.

3. Ask your dad or mom to call a local nursery to find out if there is a more natural way to control crane flies and other lawn pests.

Choice: # _____

Notes on research: _____

_____

_____

_____

_____

Question #5

Stakeholder: You

Issue: You have talked your parents into replacing some areas of lawn with native shrubs and trees. However, you are still in charge of mowing the remaining areas of lawn. What will you do with the grass clippings?

1. Put the clippings in a wheel barrow and dump them in the big ditch down the street.

2. Mow the lawn more often and leave a thin layer of clippings on top of the lawn.

3. Collect the clippings and compost them in a corner of the back yard. Use the compost in your planting beds and vegetable garden.

Choice: # _____

Notes on research: _____

_____

_____

_____

_____

Question #6

Stakeholder: A local timber company owner

Issue: You have purchased private land with large second growth trees. The land is part of a watershed that has a major stream with salmon spawning grounds and some smaller feeder streams. To make a maximum profit, you plan to log all of the land, including the trees alongside the smaller streams. You could leave some trees along the small streams, but don't think it would make a difference. You also only want to replant the logged areas with the minimum number of trees required. What do you do?

1. Log all of the trees. The little streams aren't that important.

2. Leave a one-tree wide buffer along the smaller streams. Replant the logged areas.

3. Leave a wide buffer along all the streams and replant the logged areas with extra trees.

Choice: # _____

Notes on research: _____

_____

_____

_____

_____

Activity 1

Student Worksheet "A"

Salmon Survival: Choices and Consequences

After filling out your situation cards, use this worksheet to compile your answers.

Question (Describe)	Standpoints			Your choice & why
	1	2	3	

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Salmon Survival: Choices and Consequences Answer Sheet

Activity 1

Student Handout "B"

Question 1:

Stakeholder: Manager of a local shopping mall

Issue: After 30 years, the landscaping in the parking areas at a local mall has become overgrown. The parking area covers almost 10 acres and has approximately 30 storm drains that carry runoff directly to a nearby river. Even during peak shopping times, the parking lot is never more than three-quarters full. The manager at the mall has come up with three plans to consider.

Consequences:

1. By replacing the plants with bark-o-mulch, you will increase the amount of stormwater runoff and risk the chance of flooding in parking areas. (Plant roots soak up rainwater, reducing the amount of water that runs into the storm drains.) Exposed bark-o-mulch can be washed by heavy rains from the landscaped areas and large amounts can clog storm drains, causing flooding. The loss of shade from trees also allows rainwater to heat up when the sun comes out. Heated water entering the river can harm fish and aquatic organisms -2

2. This is the wisest choice. Native plants will thrive with little care and are resistant to bugs and disease. This reduces the amount of labor time needed to maintain the plants and eliminates the use of harmful chemicals that can be carried with stormwater to the river. The plants also soak up rainwater which reduces runoff. Reducing the amount of impervious surfce also reduces runoff and natural swales will help filter pollutants. This choice not only saves money, but also helps improve water quality. +3

3. Adding even more impervious surface dramatically increases polluted, heated runoff. -3

SCORE: _____

Question 2:

Stakeholder: Local developer

Issue: A new subdivision is being built near the headwaters of a local creek. Because all of the runoff from the streets and driveways will be carried through the storm drains directly to the creek, the developer would like to include some type of stormwater treatment feature in the subdivision. Cost is an issue.

Consequences:

1. This would be a win-win situation for people and the environment. Cleaner water would be entering the creek and the cost the community pays to clean up polluted water would be reduced. Aquatic habitats would be preserved and support more species. The developer would win too; the lots may sell for a higher price to people who are willing to pay a little more for a clean environment. The only negative aspect of this plan would be the reduction of buildable land within the urban growth boundary. +3

2. This is a good solution and will help reduce pollution in the creek. However, there is a trade-off; putting the tanks underground will allow more homes to be built resulting in more impervious surface and more runoff. +1

3. Not providing any treatment for stormwater runoff would be disastrous for the creek. It would also result in lots of bad publicity and could hurt the developer's reputation in the community. -3

SCORE: _____

Question 3:

Stakeholder: You

Issue: A new house is being built in your neighborhood. You have noticed lots of dirt from the construction site is being washed into the street by the rain. The construction trucks are also leaving a trail of dirt from their tires when they leave the site. The storm drain in the street is getting clogged with all of this dirt. What do you do?

Consequences:

1. Salmon build nests in the gravel bottoms of local creeks and streams. Dirt and silt that make their way to local waterways through the storm drain system will clog the gravel bottoms of creeks and rivers. This adds up to habitat destruction for salmon. With fewer places to build spawning nests, fewer salmon survive. -3

2. You need to worry more! Not only does all of this dirt ruin spawning areas, it can also clog the gills of young fish, depriving them of oxygen. -3

3. You are a responsible young citizen who cares about salmon! The Eugene Public Works Department has erosion specialists who will work with developers to help them reduce erosion from their building sites. +3

SCORE: _____

Question 4:

Stakeholder: You

Issue: Your dad likes big, lush, green lawns. Lately, some areas of the lawn are turning brown. Your dad suspects crane flies are killing the lawn and wants to put diazinon, a pesticide, on the lawn to kill the crane fly larvae.

Consequences:

1. Pesticides don't just kill crane fly larvae, they also kill worms and the birds that eat those larvae! They also don't work on adult crane flies. Applying more than is needed is always a bad idea; the extra pesticide will wash down the storm drain when it rains or you turn on the sprinklers. Scientists have discovered some pesticides, found in even small amounts in rivers or the ocean, can destroy the sense of smell in salmon. Salmon depend on their sense of smell to migrate back to their home streams to spawn. They also use their sense of smell to detect predators. Losing their sense of smell can cause disaster in salmon populations. -3

2. This is more reponsible, but there are better ways to keep your lawn healthy. -2

3. Much better choice. There are natural products that will not harm the environment. Garden stores carry products that will control crane flies but not harm birds, children, or pets. Parasitic nematodes will also help control crane fly infestations in your lawn. Aerating your lawn, raking up extra thatch, and attracting birds to your yard will also help. You could also replace some of your lawn with native plants that thrive on less water and are resistant to pests. +3

SCORE: _____

Question 5:

Stakeholder: You

Issue: You have talked your dad into replacing some areas of lawn with native shrubs and trees. However, you are still in charge of mowing the remaining areas of lawn. What will you do with the grass clippings?

Consequences:

1. Not a good choice. During heavy rains, the ditch carries excess rainwater to the nearby creek. The lawn clippings will be carried along with the rainwater to the creek. As the lawn clippings decompose in the stream, they use up oxygen that salmon and aquatic organisms need to survive. -3

2. This is a better choice. The clippings will help retain water, reducing the need to use lots of water to keep the lawn green. As they decompose, they help fertilize too. +3

3. Another good choice. Recycling lawn clippings is good for the environment. Using the compost as a natural fertilizer reduces the need for chemical fertilizer and saves money. +3

SCORE: _____

Question 6:

Stakeholder: A local timber company owner

Issue: You have purchased private land with large second growth trees. The land is part of a watershed that has a major stream with salmon spawning grounds and some smaller feeder streams. To make a maximum profit, you plan to log all of the land, including the trees alongside the smaller streams. You could leave some trees along the small streams, but don't think it would make a difference. You also only want to replant the logged areas with the minimum number of trees required. What do you do?

Consequences:

1. The small streams are important! In a watershed, smaller streams flow into the main stream. Logging all of the trees along the small streams increases erosion. Dirt and debris from erosion will be carried from the small streams into the main stream. Removing the trees also exposes the water in smaller streams to the hot sun, increasing water temperature. Salmon need cool, clean water in order to spawn and survive. Silt, debris and increased water temperatures will combine to destroy the salmon habitat. -3

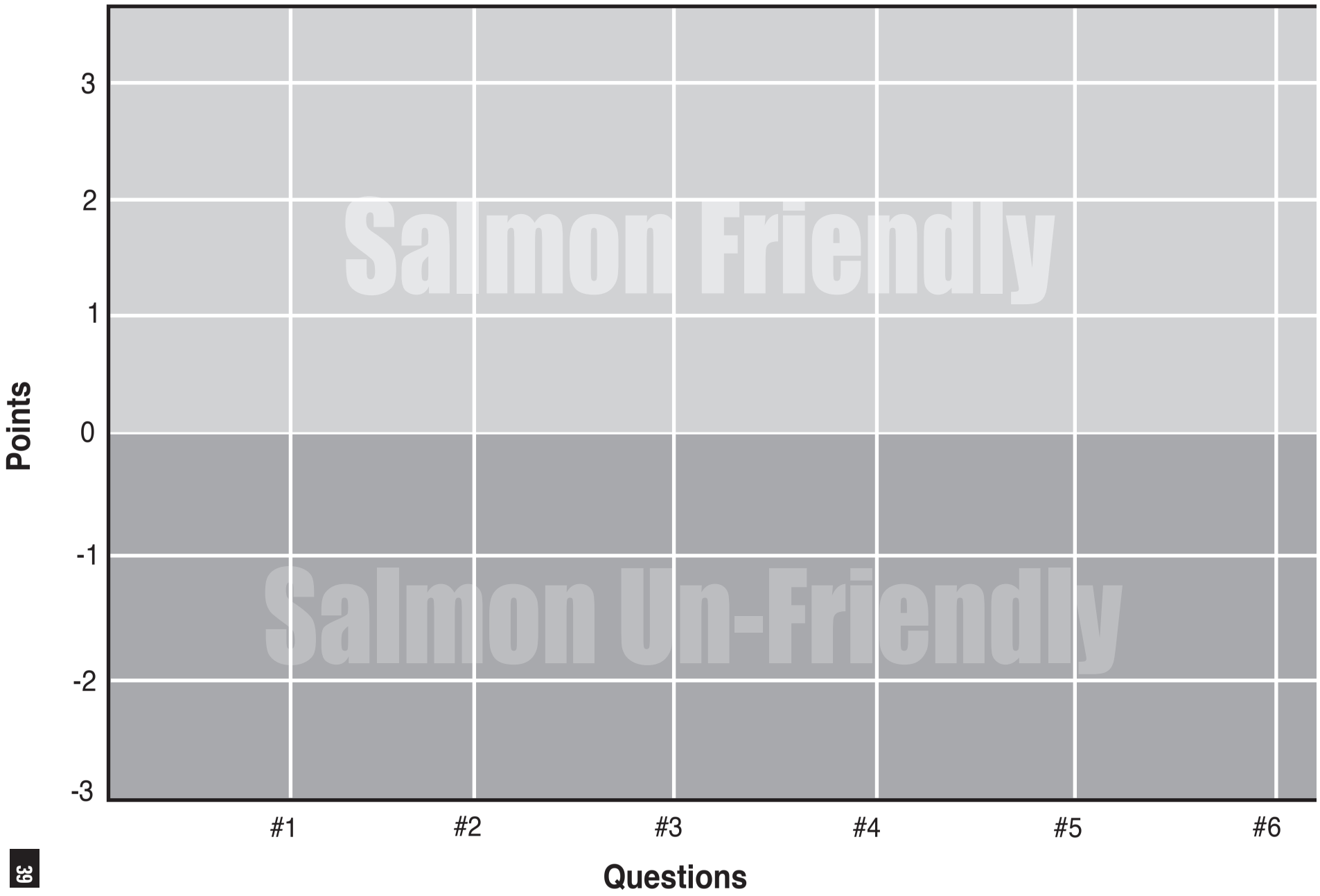
2. This is better, but not good enough. A one-tree buffer won't stop the erosion and will provide only a little shade during part of the day. And, replanting with only the minimum amount of trees may not replace all of the trees that were logged since some of the transplants will be eaten by wildlife or killed by disease or insects.-3

3. Although not as profitable, this is an environmentally responsible choice. +3

How did you score?

Chart your points for each question on the chart provided. The more positive choices you make, the greater the chance for salmon survival.

Issues and Consequences: Chart your points and see how your choices impact salmon survival



Stormwater Pollution Match-up Game

Activity 2

Teacher's Instructions

This game will teach students how common pollutants that make their way onto local waterways can harm salmon during specific stages of their life cycle.

Time Needed:

Approximately one hour.

Instructions:

Divide students into groups of four or five. For each group, place cards depicting the stages of the salmon life cycle and the cards showing pollutants face up (pictures up) on a table. Have students match a pollutant card with a life cycle card. When each life cycle card has a pollutant card matched with it, have students turn over the life cyle card to see if they have correct choices. If they have incorrectly matched the cards, have them try again and until all of the correct matches are made. Once the cards are all correctly matched, have the students turn over the pollutant cards and read information about where the pollutants originate.

After playing the game, ask students if they have seen any of these pollutants in their neighborhoods or their home. Have the entire class brainstorm ways to keep these pollutants out of local waterways.

Extensions:

Copy, distribute and discuss three additional handouts: *Salmon Decline Affects Everyone*, *The Facts about Chinook Salmon*, and *Salmon Through the Ages*.

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Stormwater Pollution: Learn and Share

Activity 3

Teacher and Student Handout "A"

Can lawns kill salmon?

This activity has been developed to provide hands-on experience in water sampling and testing to determine the presence of 2,4-D and other pesticides in Delta Ponds. This site was chosen for sampling due to its proximity to large residential areas where weed and feed products containing 2,4-D are used by homeowners and because of the ecological importance of the ponds in the life cycle of the chinook salmon. Before starting the activity, please read this background information.

Introduction and background

Throughout the United States, lush, green expanses of lawn are an urban status symbol. In fact, if classified as a "crop," lawn would be the fifth largest crop in the United States. American's passion for their lawns has driven the lawn care industry to boom and lawn care products to be best sellers.

In an average year, American homeowners collectively use almost 70 million pounds of pesticide on their lawns.[1] The most commonly used commercial lawn product is "weed and feed," a convenient combination of chemical fertilizer and broadleaf herbicide. Easy to use, weed and feed products can give homeowners a green, weed-free lawn with little expended effort. Unfortunately, the product that makes life easy for homeowners can cause great harm to people, animals, and the environment.

Almost all weed and feed products contain 2,4-D, a neurotoxicant that is associated with some types of cancer and disruption of the endocrine system. Exposure to 2,4-D is most harmful to children, pets, birds, fish and wildlife. Any living organism, whether human or animal, is most susceptible during the younger stages of life when cells and tissues are growing.

Pesticides have been detected in almost every water body in the United States and 2,4-D is one of the most common pesticides found. A study conducted in 1999 by the U. S. Geological Survey (USGS) found levels of 2,4-D in the Willamette River and Puget Sound exceeded criteria set to protect aquatic life.[2] The Willamette River is crucial habitat for salmon and other salmonid species. The presence of 2,4-D, along with high levels of more than 26 other pesticides, contributes to the decline of salmonid species.

In Oregon, weed and feed is commonly applied in April and May, coinciding with spring storms. (Studies have shown a direct correlation between peak local sales of lawn care products and the presence of 2,4-D in nearby waterways.) Despite often abundant spring rains, many homeowners

How does 2,4-D kill weeds?

When sprayed on broadleaf weeds, 2,4-D causes abnormal plant growth that plugs the xylem and phloem. Unable to transport nutrients, the plants die. You could say 2,4-D causes plants to literally grow themselves to death!

Lesson Summary:

1. 2,4-D is one of the most common pesticides found in water samples (rivers, streams, ponds)

2. Weed and feed products are used by homeowners, turf managers at golf courses, and cemetery caretakers

3. Weed and feed products are often over-applied or improperly applied

4. Excess weed and feed is carried into storm drains by [our] abundant rainfall or improper watering

5. 2,4-D adheres to soil particles washed down storm drains. The half-life of 2,4-D is short, so greatest risk to fish is during storm events, especially after a number of warm, dry days ("pollution pulses").

6. Concentration of 2,4-D in water samples increases in April and May

7. 2,4-D is easily absorbed by aquatic organisms and juvenile salmon are very susceptible to exposure of 2,4-D

8. 2,4-D interrupts energy production in animal cells by depleting available adenosine triphosphate (ATP)

9. Depletion of ATP results in loss of muscle contraction

10. Loss of muscle contraction in juvenile salmon impairs swimming ability, resulting in inability to feed, escape predators or migrate back to sea

also start using their sprinkler systems in early spring, increasing the amount of water lawns must absorb. Lawns become over-saturated and weed and feed applied at the wrong time or in excess amounts runs off the lawn and into the storm drain system that dumps directly into local waterways. Many pesticides, including 2,4-D also adhere to soil particles and are carried to waterways with eroded soil.[3] Pesticides are carried in creeks and streams to areas far downstream from the original source of pollution.

Waterways near residential areas are most susceptible to pollution from pesticides carried with stormwater runoff. In Eugene, juvenile salmon are found in stream or ponds located near residential areas and places with new home construction. Exposure to pesticides, especially 2,4-D has been found to harm fishes' swimming ability (Lind, 2002) and, in high doses, cause mortality. Juvenile salmon are very vulnerable to any chemical exposure and are more likely to be harmed than adult fish.

Many studies have indicated 2,4-D is an endocrine disrupter. In fish, 2,4-D depletes adenosine triphosphate (ATP), causing a loss in muscle contraction. In juvenile salmon, the ability to swim, feed and escape from predators is impaired. 2,4-D also inhibits the synthesis of DNA.

In this activity, water samples will be collected from the Delta Ponds and the samples will be tested for the presence of 2,4-D and other pesticides.* (See Handout *Method 8151A* for a list of herbicide compounds tested.)

Discussion Questions:

1. Explain the function of *xylem* and *phloem* in plants.

2. How do broadleaf herbicides kill plants?

3. Why doesn't 2,4-D kill grass?

4. How can a chemical pesticide designed to kill plants be harmful to animals?

5. What is the function of adenosine triphosphate (ATP) in muscle contraction?

6. List three functions of voluntary (striated) muscle and involuntary (smooth) muscle.

7. How can the loss of muscle function harm juvenile salmon?

---

[1] Environmental Protection Agency, 1991.
[2] USGS, 1999.
[3] Barbash et al (1996) in Ewing (1999)

*Testing can be done by Columbia Laboratories in Kelso Washington. The cost for testing is approximately $175.00 per sample.

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Activity 3

Teacher Instructions

Can lawns kill salmon?

This activity can be taught over a few weeks or can be used in a shortened, modified version if time does not allow for full participation. The instructions include shorter alternatives to the complete activity.

1. Distribute **Teacher and Student Handouts "A, B and C"** and **Supplemental Handouts "A and B."** Have students answer discussion questions included in **Teacher and Student Handouts "A and B**."
2. Copy and distribute cards to teams. Have them use the cards to organize their teams and list team responsibilities. Teams will meet to produce an outline of their tasks, including timelines and individual assignments.
3. Arrange for transportation to and from the test site.
4. After all teams have completed their tasks and test results are revealed, have a final discussion and debriefing.

This activity can be also taught in a shortened version by reducing the number of teams and using discussion questions taken from Teacher and Student Handouts "A and B."

1. Have students choose to participate on the Safety Team or Sampling Team.
2. Have students follow instruction for team responsibilities.
3. Follow procedures to collect one water sample from Delta Ponds.
4. After reviewing the results, discuss the questions from **Teacher and Student Handouts "A and B**."

If it is not possible to have your class form teams or do any field work, you can access the results from other classes. Results will be posted on the 4J website. Contact John Bezelj at 687-3526 or bezelj@4j.lane.edu for more information.

***Note:** This activity should be scheduled to coincide with spring storm events that occur from mid-April to early May. This is also the time period when the sale and use of weed and feed products increases.*

SPLASH!
Stormwater Pollution: Learn and Share

Activity 3

Teacher and Student Handout "B"

Can lawns kill salmon?

Water Quality in Eugene: Delta Ponds

The Delta Ponds were once part of the network of sloughs created by the Willamette River. The ponds were created when gravel was excavated to build Delta Highway. Over the years, vegetation has covered the banks and the ponds have become populated by fish, birds and other wildlife.

The Delta Ponds are one of the few remaining quiet, backwater habitats left on the Willamette that serve as a resting and feeding place for many species, including juvenile Chinook salmon. Flood control management and land use practices have reduced the amount of backwater habitat along the Willamette that is critical to salmon survival. Currently, a restoration project is being conducted at Delta Ponds to improve habitat for fish and wildlife. Non-native vegetation is being removed from the ponds and the steep banks are being reshaped to create more riparian areas. Work is also being done to reconnect the ponds to the river for a better exchange of water, and allow juvenile salmon to enter the ponds. New culverts will also allow water flow between the river and the ponds on the west side of Delta Highway and between the ponds on the west and east side of the highway. The restoration of Delta Ponds will provide critical habitat for juvenile salmon, threatened pond turtles and other species.

Residential areas near the ponds may be a source of pollutants that could impact this critical habitat. Stormwater runoff from streets and yards often contains pesticides, oil, silt, heavy metals (from cars) and garbage. (*See Activity 4: Stormwater Pollution Match-up Game.*)

Studying water quality in the Delta Ponds is important. The presence of 2,4-D and other pesticides could have an impact on how the ponds are managed as a habitat for sensitive species.

Discussion Questions:

1. How were the Delta Ponds formed?

2. What is a "riparian area?"

3. Why are the Delta Ponds important in the life cycle of Chinook salmon?

4. How does stormwater runoff enter Delta Ponds?

Can lawns kill salmon?

Activity 3

Teacher and Student Handout "C"

This lesson is a real-life experience in water quality testing and research. The goal is to make a connection between human behavior, in this case the use of weed and feed products on lawns, the conveyance of these chemicals to local waterways via the storm drain system, and the impact on sensitive species.The results will only be valid if proper testing procedures are followed. Working in teams will help facilitate this complex activity. Use the following outline as a guide to develop teams and assign responsibilities:

Coordination Team

1. Determine monitoring frequency and event targeting

a. Determine how frequently samples will be collected.
b. Determine under what conditions sampling will be performed; if sampling is to be done in conjunction with storm event describe how weather forecasts are to be monitored including describing criteria for selecting a specific storm event
c. Will sampling event be based on:
   Precipitation accumulation – rain gauges?
   Stormwater flow – flow measurements?

2. Oversee the work of all teams and schedule periodic meetings to review objectives and responsibilities, and check progress on assignments

Safety Team

1. Study safety protocol and develop a Health and Safety Plan for the Sampling Team

a. Assign key personnel, safety responsibilities, and provide worker training (if necessary)
b. Develop a site control plan
c. Develop a buddy system; determine communications
d. Identify any physical and biological hazards at the site
e. List and obtain necessary personal protective equipment
f. Prepare emergency preparedness & response plan, include site and hospital map in case of accident

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Stormwater Pollution: Learn and Share

Activity 3

Teacher and Student Handout "C"

Sampling Team

1. Review sampling procedures (clean sampling techniques), properly prepare sampling equipment, collect samples and prepare them for testing.

a. Review general requirements for personal safety (see *Health & Safety Plan* for specifics)
b. Prepare & decontaminate field equipment (Supplemental Handout "A")
c. Organize bottles
d. Keep chain of custody records
e. Work with City of Eugene staff to transport, package, and ship samples from the field to the laboratory

Mapping Team

1. Review maps (provided) to identify outfalls, catch basins and potential pollution sources

a. Describe land uses and acreages – include important boundaries, site geology and hydrology
b· Study stormwater system network and locate potential sources of pesticide contaminants. Describe these locations and delineate on map
c. Investigate DEQ's web site for potential hazardous waste (pesticide, etc.) clean-up sites that may affect study area; describe and delineate on map
d. Describe criteria for sampling location selection and identify sampling locations on map
e. Provide photographic documentation of sampling locations

Research Team

1. Analyze the results of the water quality tests and research and gather information about how exposure to the pesticide 2,4-D adversely impacts juvenile salmon and other aquatic species.

a. Analyze results of lab tests, compare levels of 2,4-D in sample with criteria set by U. S. Geological Survey set to protect aquatic life
b. Identify other pollutants found in results and determine source of origin
c. Research how 2,4-D affects juvenile salmon and prepare report on consequences of exposure to 2,4-D (focus on cell processes)
d. Present findings to entire class

Public Relations Team

1. Develop a public relations campaign targeting local homeowners with the goal of reducing pesticide use.

a. Determine target audience
b. Develop a list of goals for public relations campaign
c. Create "key statements."
d. Develop fact sheets to inform target audience about the problem and potential solutions
e. Identify media resources and write news releases

The **Coordination Team** will oversee the work of all teams, schedule periodic meetings to review objectives and responsibilities, and check progress on assignments. Participating on this team will give students the opportunity to practice leadership skills. This team will include Storm Event Coordinators who will track weather systems and choose the best date for testing.

Tasks:

Assignments:

Work Outline:

The **Safety Team** will study safety protocol and develop a safety plan for the Sampling Team. They will be responsible for collecting and providing safety equipment which will include a harness, life preservers, hip boots, safety glasses and any other equipment identified in the safety plan.

Tasks:

Assignments:

Work Outline:

The **Sampling Team** will review sampling procedures (clean sampling techniques), properly prepare sampling equipment, collect samples and prepare them for testing. The team will choose members to collect samples, label bottles or vials and pack for shipping. The Sampling Team will work closely with the Safety Team.

Tasks:

Assignments:

Work Outline:

The **Mapping Team** will review **Stormwater Flow to Delta Ponds** map to identify outfalls, catch basins and potential pollution sources. A topographic map will be used to describe land uses, site geology and hydrology. Maps will be provided. The Mapping Team will work closely with the Sampling and Public Relations Teams.

Tasks:

Assignments:

Work Outline:

The **Research Team** will analyze the results of the water quality tests and research and gather information about how exposure to the pesticide 2,4-D adversely impacts juvenile salmon and othe aquatic species. (Research should focus on how cell processes are disrupted.) The Research Team will create a report and present findings to the class.

Tasks:

Assignments:

Work Outline:

The **Public Relations Team** will develop a public relations campaign with the goal of convincing the target audience to reduce pesticide use. The campaign may be developed using community-based social marketing principles.

Tasks:

Assignments:

Work Outline:

SPLASH!
Stormwater Pollution: Learn and Share

Salmon of the Future: Changes and Adaptations

Activity 4

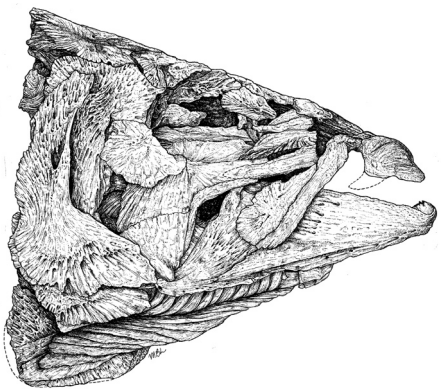
Teacher and Student Handout "A"

What were salmon like millions of years ago and how will they look in the future? Use this activity to review the life history, physiological functions and physical attributes of salmon and predict how environmental changes will influence salmon in the future.

Introduction

Fossil evidence has helped scientists identify almost 30 different species of salmonid fish in western North America. Salmon in the Pacific Northwest evolved and changed in response to global weather changes, including the ice ages, and other natural factors. For example, salmon evolved from a freshwater life cycle to an anadromous life cycle to take advantage of the nutrients available in the ocean. Some salmonid species, like the saber-toothed salmon (see sidebar below) that lived in rivers in the Pacific Northwest and California, were lost during the mass extinctions of the Miocene and early Pliocene epochs of Cenozoic era.

In modern times, human-caused changes to the environment have impacted salmon species. Loss of habitat, damming of rivers, expansion of urban areas, water pollution and other factors have all contributed to reduced salmon populations and caused the extinction of some salmon stocks. In the future, salmon and other species may need to adapt to even more drastic changes in the earth's environment. Increased pollution, global warming, acid rain and other changes could all influence salmon populations. To survive, salmon must adapt to changes in their ecosystem.



The saber-toothed salmon

In 1917, paleontologists in California discovered fossil remains of a giant, unfamiliar fish. After similar fossil finds in 1950 and 1964, this fish was finally identified as a primitive salmon-like species that lived in the Pliocene epoch at the same time as salmon species we are familiar with today. The saber-toothed salmon (*Smilodonichthys rastrosus*) possessed two large, fang-like teeth in the upper jaw that may have been used to fight other salmon during breeding season. These salmon also had over 100 toothless gill rakers, which may indicate they spent part of their life in the ocean feeding on small organisms.

Illustration used with permission from the University of Oregon Museuem of Natural and Cultural History

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Activity 4

Teacher and Student Handout "A"

Lesson Summary

1. An ancient ancestor of salmon, *Smilodonichthys rastrosus*, the saber-toothed salmon, lived in rivers in eastern Oregon. Like many species of their time (Miocene and early Pliocene epoch), they are now extinct.

2. Salmon evolved from a freshwater life cycle to an anadromous life cycle to take advantage of the nutrients available in the ocean.

3. Environmental changes and global weather changes affect ecosystems and habitats for many species.

4. Destruction of and changes to salmon habitat have resulted in drastically decreased numbers over the last 100 years

5. Many other species have adapted rapidly to temporary ecosystem changes (e.g. Recent changes in sea lion behavior in Columbia River. Reduced salmon runs have resulted in sea lions traveling to Bonneville Dam and up the Sandy River to look for fish; sea lions have been taking salmon from fishermen's lines and showing aggression toward fishermen)

6. To survive, species must adapt to changes in their ecosystems.

Activity:

In this activity, you will identify environmental changes, predict how changes will influence salmon and design a physical model of salmon of the future.

Discussion Questions:

1. What did salmon look like five million years ago and how have they changed to their present day form? What influenced these changes?

2. Identify current and future environmental changes that may impact salmon. Example: acid rain.

Instructions:

1. Use **Student Handout "A,"** to list how the changes discussed will affect the life history of salmon along with physical and physiological structure of salmon.

2. Develop a physical prototype of a future salmon based on adaptations to changes. (Use the back of **Student Handout "A"** to sketch potential prototypes.) Work in "teams" to choose materials and construct the prototype. Be creative!

3. Develop a presentation, display your prototype and explain what factors influenced your choices.

Salmon of the Future: Changes and Adaptations

Activity 4

Student Handout "B"

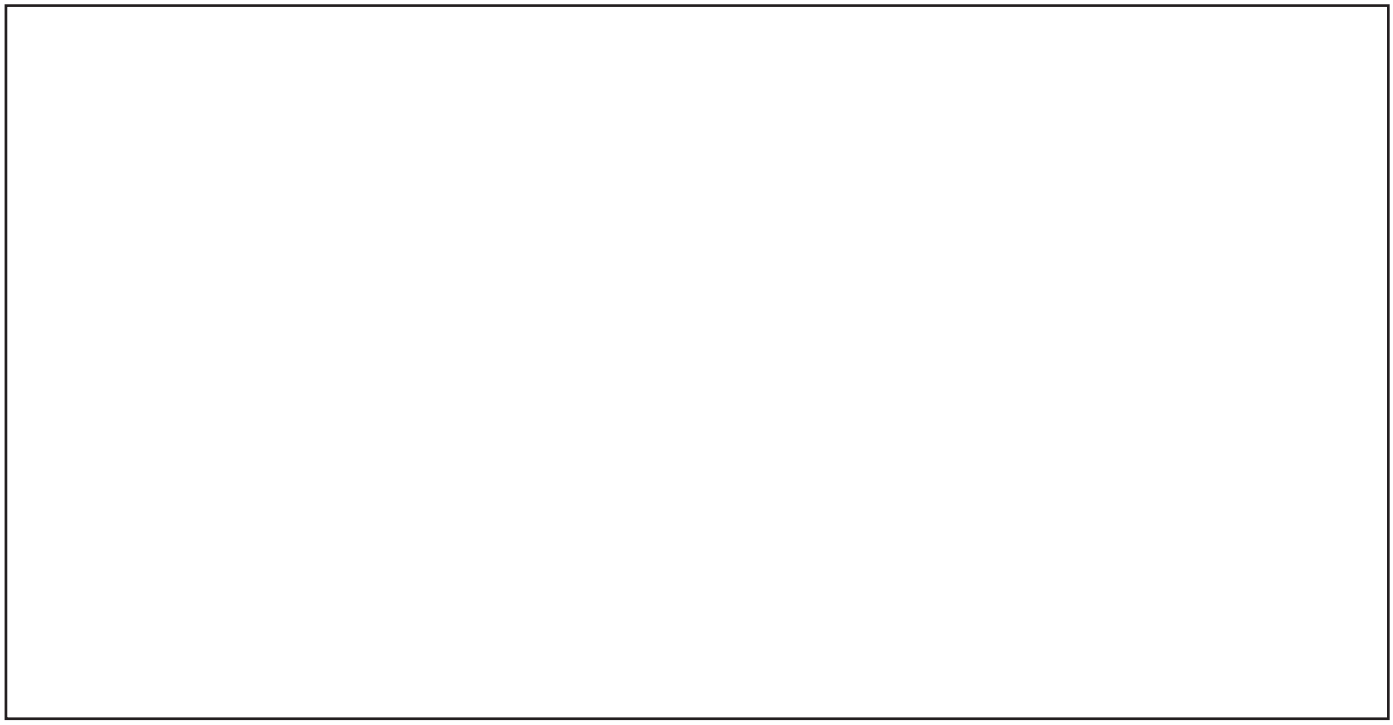
Worksheet: Use this worksheet to list influences that will shape your salmon of the future and the adaptations that may occur.

Things to consider:

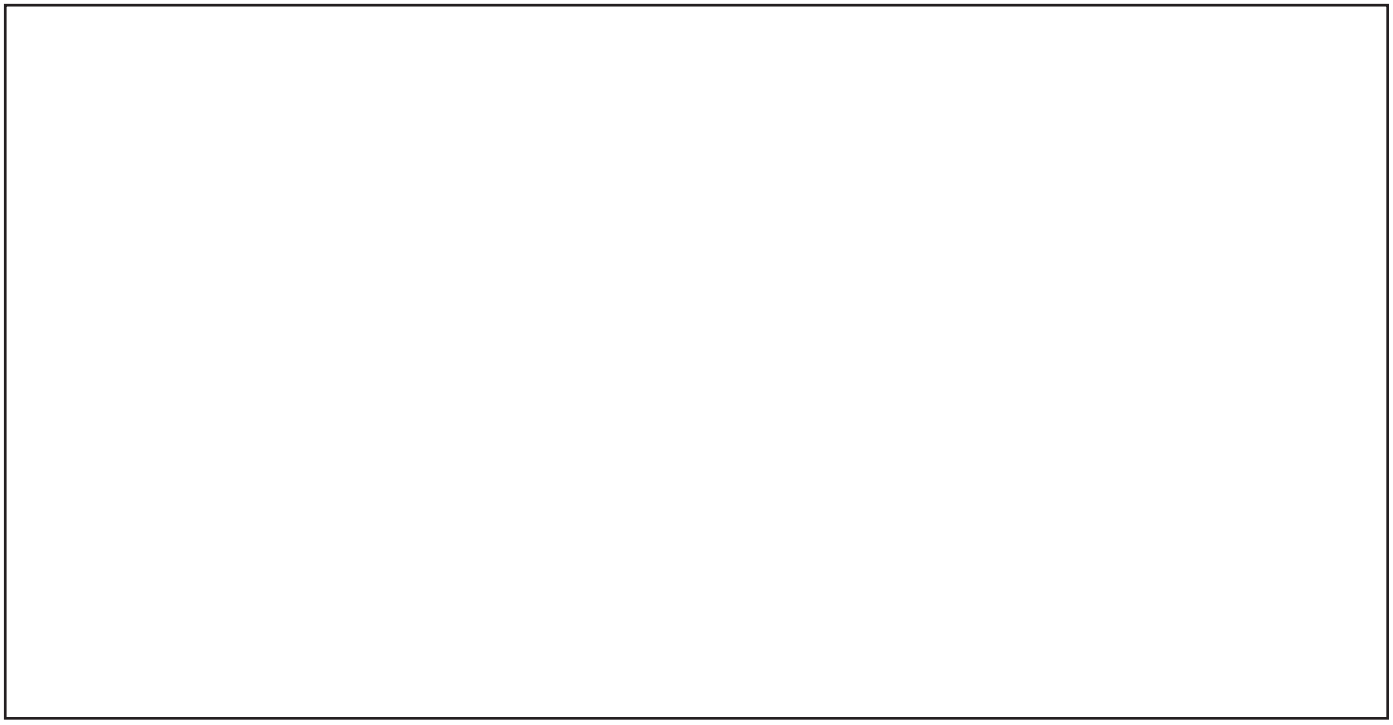
1. **Life history**
   Example: migration,
2. **Physiological functions**
   Example: locomotion
3. **Physical attributes**
   Example:body shape

Environmental change:	*Adaptation:*

Sketch your "future" salmon.



Materials list for construction: _____



Materials list for construction: _____

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Activity 5

Student handout

Salmon and Sitka Spruce:

A Mutually Dependent Relationship

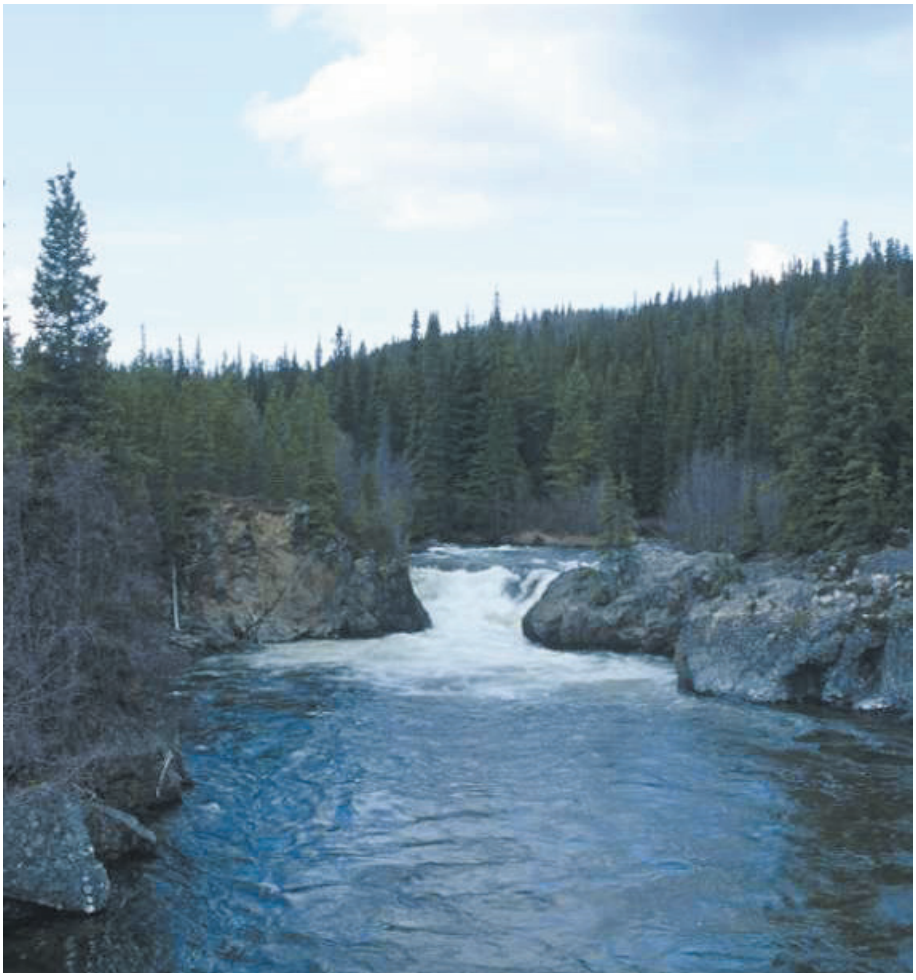
Students: After reading the following article, answer the questions on the back page.

Teachers: Lead a class discussion allowing students to compare answers to each question. Use the discussion as a basis to explore the relationships between species.

The relationship between the salmon and the forest is intriguing and complex. Many studies have been conducted to explore how the presence of spawning salmon influences the health of streams and the adjacent riparian areas. Although it is known that the marine-derived nutrients from the decaying bodies of spawned-out salmon are spread throughout the stream and surrounding riparian areas, how much does this natural fertilizer effect tree growth along stream banks? In one case, the results were quite surprising.

In a study done on two streams in Alaska, researchers discovered a significant difference in the growth rates between Sitka spruce trees that grow along streams where salmon spawned and trees upstream from spawning areas (Helfield and Naiman 2001). These two streams support dense runs of pink salmon and smaller runs of coho and chum salmon. The study found that spruce trees along spawning sites had a growth rate that was more than three times faster than spruce trees in upstream areas not influenced by salmon. The conclusion was that the decaying bodies of spawned-out salmon provided tremendous amounts of nutrients that contributed to the accelerated growth of the spruce trees.

The relationship between the salmon and the spruce tree is not just a one-way street. The larger spruce trees have a very positive



Sitka spruce along an Alaskan stream

impact on the stream habitat necessary for salmon survival. Larger trees provide more shade, which helps moderate water temperatures, creating ideal conditions for salmon reproduction. The larger root systems of the spruce trees stabilize stream banks and filter sediment, reducing erosion into the stream, which increases the rate of survival of salmon embryos. Leaf litter from the trees falls into the stream, providing organic nutrients for insects that are an essential part of the juvenile salmon's diet. Stream habitat is also enhanced by fallen trees. Large woody debris in streams helps moderate flow, protecting salmon embryos and fry from being washed downstream by high winter flows. Downed trees also trap sediment, keeping spawning beds free of silt that can suffocate developing embryos. Again, larger trees make a difference. Due to the increased heights of the spruce trees, even trees farther away reach the stream banks when they fall.

The mutually dependent relationship between the salmon and these Sitka spruce trees has evolved over millions of years. Traditionally, fisheries management has focused on a single-species model where salmon were regarded only as a commercial resource. This model ignored the relationship between salmon and their ecosystem. The realization that salmon is the keystone species in a complex ecosystem is a fairly recent discovery. As people learn and understand more about salmon and forests, new management strategies can be developed to ensure the survival of wild salmon.

Bibliography

Helfield, J. M. and R. J. Naiman. 2001. "Effects of salmon-derived nitrogen on riparian forest growth and implications for stream productivity." Ecology 82: 2403-2409.

Questions for discussion:

1. What is the difference in the growth rate of the spruce trees along salmon spawning sites and upstream where salmon do not spawn?

2. Explain two ways the salmon are helping the Sitka spruce trees.

3. Explain two ways the Sitka spruce trees are helping the salmon.

4. After reading about the mutually dependent relationship between the Sitka spruce and salmon, name other species that have a dependent relationship with salmon. Explain the relationship.

5. Think of other similar dependent relationships between species. Describe how the relationship works.

6. In a dependent relationship between species, what happens when one species is removed or no longer a factor?

7. If there are two streams that are almost identical (topography, location), but one has a salmon run and the other doesn't, explain how the two streams might be different.

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Tyee's Magnificent Journey

Activity 6

Teacher's Instructions

This activity was taken and adapted from Activity Two in The Fish Hatchery Next Door. This activity is meant to be an introduction to the life-cycle of a salmon and various factors that influence their survival.

Amount of Time Needed:

Introduce the activity and give the students 60-90 minutes to read the information and prepare their presentations. Once they're ready, it takes about 30 minutes to present.

Materials:

Student packets of Tyee's story (copy from master in back pocket of this binder)

Over-head sheets and/or poster making supplies

Student cards with directions

Activity Directions:

1. Make a class set of the story of Tyee.
2. Copy student cards 1-6
3. Split the class into six groups.
4. Each group is given a different topic to report to the rest of the class. The topics are:

a. **Salmon Mortality:** come up with a creative way to present fish numbers and percent of deaths (those who survived versus those who did not) to the class.

b. **Map of the Journey:** map out the journey Tyee takes from her place of birth, through her life, back to her place of death. (See the map provided.)

c. **Stream Morphology:** map out a stream with its different physical attributes and discuss.

d. **Human and Natural Impacts:** present the factors of human and natural (both positive and negative) influences on salmon.

e. **Salmon Adaptations:** present adaptations that salmon go through (changes) in order to survive in their environment.

f. **Salmon Life cycle:** present the salmon life cycle.

Tyee's Magnificent Journey • Student Card 1

Salmon Mortality:

Your task is to present the information about salmon mortality to the class.

Use a creative way to present fish numbers and percent of deaths - those who survived and those that did not.

Tyee's Magnificent Journey • Student Card 2

Map of Journey:

Your task is to map out the journey Tyee takes from her place of birth, through her life, back to her place of death.

Tyee's Magnificent Journey • Student Card 3

Stream Morphology:

Your task is to map out a stream, showing the physical attributes of a stream and how these attributes affect salmon.

Tyee's Magnificent Journey • Student Card 4

Human and Natural Impacts:

Your task is to present the factors of human and natural influence on salmon. These impacts can be positive or negative.

Tyee's Magnificent Journey • Student Card 5

Salmon Adaptations:

Your task is to present adaptations that salmon go through (changes) in order to survive in their environment. What are some characteristics that have helped them to escape predators?

Tyee's Magnificent Journey • Student Card 6

Salmon Life Cycle:

Your challenge is to present the salmon life cycle. What are the different stages of development? How long does each stage last? Where does each stage take place?

The Salmon Food Chain and Food Web

Activity 7
Teacher's Instructions

Activity 7, Part 1:
The Salmon Food Chain

This exercise will help students understand how nutrients and energy are passed through the "food chain" and how many food chains can be integrated to create "food webs."

Before beginning the exercise, provide students with the handout, *Salmon, The Food Chain and Food Web*. Review the handout and discuss the salmon food chain and food web. After discussing the handout, begin the activity.

Materials Needed:

Ball of String
Nametags (provided)

1.Assign students to be elements and organisms in the salmon food chain using the name tags provided. Elements and organisms included:

Sun
Phytoplankton
Zooplankton
Squid
Salmon
Killer whale

Create a simple food chain:

Using six students, hand out nametags depicting the species that are part of a simple salmon food chain. Starting with the sun, have students form a chain. Using a ball of string, connect the food chain by passing the ball to each member and having them hold onto the string with one hand. To create "stress" within a food chain, have students pull on the string until it breaks. Ask the students the following questions. What link was broken? How will the break affect the rest of the food chain?

Activity 7, Part 2:
The Salmon Food Web

Adapted from an activity developed by the Vancouver Aquarium Maine Science Center, Vancouver, British Columbia.

To discover how important salmon are to the Northwest ecosystem, change the **Food Chain** exercise to make salmon the central species in a **Food Web**. Divide the class into groups so all students can participate.

Materials needed:

String
Nametags (provided)
Research cards

1. Assign students to be biotic and abiotic elements in the salmon ecosystem using the name tags provided. Elements include:

sun	air	water	stonefly	herring	merganser
bear	mayfly	Sitka spruce	krill	sea lion	decomposers
log	frog	eagle	shrimp	redd	scat
mosquito	trout	salmon	fisherman	killer whale	orca
fungus	stream	plankton	ocean	gravel bar	cottonwood

2. As an assignment before the activity, copy and distribute **Activity 7, Student Worksheet 1**. Have students to research the relationship their element has with other elements in the food web.

3. To begin the activity, have the "salmon" to stand in the middle of an open area. Give the salmon a piece of string and have them name something they need to survive. Give the other end of the string to the student wearing that nametag. That student will then name something they need to survive or something that relies on their element for survival and join strings with that student. (Be sure students choose the elements listed above.) Continue until all of the students are connected in some way.

Introduce human activities that could harm the ecosystem. Brainstorm with students to create a list of other factors that could be harmful. Examples include road building along a stream, chemical pollutants and fertilizer carried into a waterway with stormwater, and heated water from industrial discharge. Which elements or organisms in the food web would be affected by each of these factors? After identifying harmful factors, remove the element or organism that is impacted. How does this weaken the food web?

Examples:

1. Road building removes trees and adds silt from erosion to the stream. Increased sunlight from the loss of trees raises water temperature, which increases the incidence of disease in salmon. Silt smothers salmon eggs and ruins spawning areas. The **stream** and the **salmon** would be impacted.

2. Chemical pollutants can reduce growth rates in young salmon; some chemicals can kill juvenile and adult salmon. Pollutants also kill the aquatic insects young salmon depend on for food. The **mayfly, frog, fish,** and **salmon** would be impacted.

3. Fertilizer introduces nitrogen into the waterways, which causes large algae blooms (excess growth of algae). As the algae dies and decays, it uses up oxygen, leaving little for aquatic organism and fish. The **mayfly, frog, fish**, and **salmon** would be directly impacted.

4. Heated water from industrial discharge raises water temperatures. Salmon will only spawn in cool water. The stream, mayfly, fish, frogs, and salmon would be directly impacted.

Extension 1 of Food Web Exercise:

Scientists have found ocean elements (nitrogen and carbon isotopes) far inside inland forests. (See page 8, Salmon Need Forests…and Forests Need Salmon!) One of these elements, ^{15}N, carried from the ocean by salmon, has been found in trees, insects, and soil far from streams where salmon spawn.

To simulate how these elements are carried from the ocean to the inland forest, use a large marshmallow to represent a marine-derived nitrogen isotope. Hand the marshmallow to a bear, eagle, any tree, any insect, fungus, or scat. Have students brainstorm to determine how the element entered the organism. An example might be: an animal that feeds on salmon dies near the tree and decomposes. The organic matter acts as fertilizer for the spruce tree; nutrients and the ocean elements are absorbed by the trees roots.

Discussion Questions:

How important is the salmon in the food chain (or web)?

How is the food chain (or web) impacted by the loss of salmon?

Can any other species replace the salmon in the food chain (or web)?

What Is My Role in the Ecosystem?

Interactions within an ecosystem can be complex. Within the food web, some organisms can be predators as well as the prey of other organisms. This exercise will help you understand the relationships between organisms.

Activity 7

Student Worksheet 1

Elements in my ecosystem:

sun
air
water
stonefly
herring
merganser
bear
mayfly
Sitka spruce
krill
sea lion
decomposers
log
frog
eagle
shrimp
redd
scat
mosquito
trout
salmon
fisherman
killer whale
orca
fungus
stream
plankton
ocean
gravel bar
cottonwood

Which organism am I?

_____

Which organisms depend on me? Why?

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Which organisms or elements do I need to survive? Why?

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